Environmental Concerns in the Athlete

A Primary Care Sports Medicine Perspective

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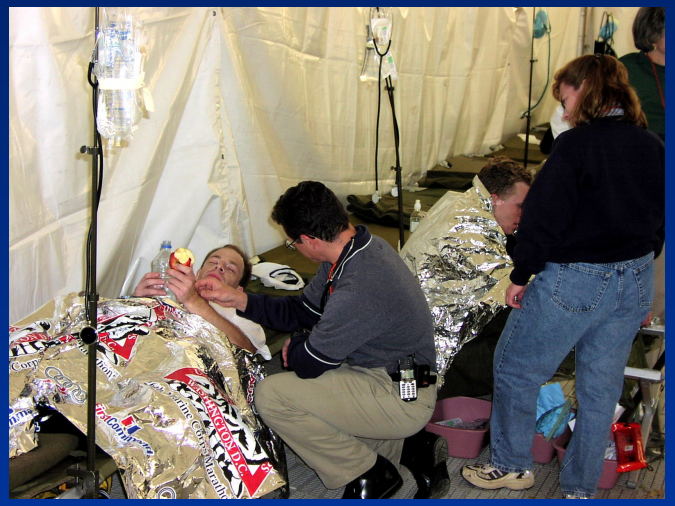
Objectives

- Review the terminology and pathophysiology of environmental disorders in the heat, cold and at altitude.
- Discuss current concepts and guidelines in the management of these disorders as applicable to the sports medicine clinician.



Clinical Scenario I

You are covering a triathlon, when you are asked to evaluate a swimmer who is removed from the water as he is unable to effectively swim. He is not shivering and has a heart rate of 60 bpm. What body temp range is he in and what would be an effective management strategy at this point in time?

Hypothermia

Hypothermia - Definitions

- Hypothermia: decline of 2C or 3.6F in normal human core temperature (37C or 98.6F)
- Passive re-warming: prevent further heat loss.
- Active re-warming: apply external or internal (core) source of heat.
- After-drop: further cooling of the body core after removal from cool environment; cool blood from periphery returns to the core.
- Rewarming shock: vascular collapse during re-warming; secondary to depressed myocardium, vasodilation and hypovolemia.

Classification of Hypothermia

- Mild Hypothermia:
  – 90F (32C) – 95F (35C)
- Moderate Hypothermia
  – 82F (28C) - <90F(32C)
- Severe Hypothermia
  – <82F (28C)

Mild Hypothermia

- Clinical Recognition:
  - Increase in metabolic rate, blood pressure and shivering muscle tone
  - Amnesia, poor judgment, dysarthria
  - Tachycardia progressing to bradycardia
  - Cold diuresis
  - Apathy and ataxia

Moderate Hypothermia

- Clinical Recognition:
  - Stupor
  - Extinguished shivering
  - Atrial arrhythmias
  - Paradoxical undressing
  - Pupils dilated; progressive decrease in consciousness

Severe Hypothermia

- Clinical Recognition:
  - No reflexes or response to pain
  - Significant hypotension and bradycardia
  - No corneal or oculocephalic reflexes
  - Hypoventilation
  - Maximum risk for ventricular fibrillation

General Treatment Hypothermia

- Handle all victims of moderate and severe hypothermia carefully to avoid unnecessary jostling or sudden impact.
  - Prevent further heat loss; insulate victim from above and below.
  - Anticipate irritable myocardium, hypovolemia, and a large temperature gradient between the periphery and the core.
  - Treat hypothermia before frostbite.

Auerbach et al: Field Guide to Wilderness Medicine 2nd Ed. Mosby, 2003.

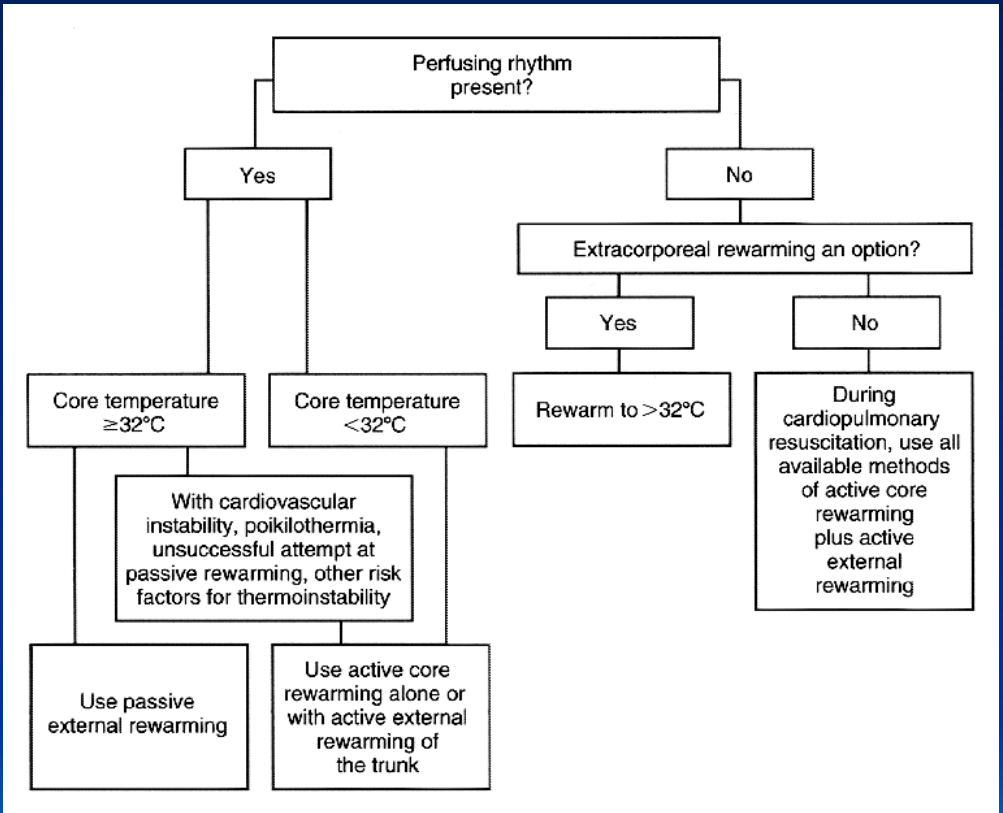
Mild Hypothermia

- Passive re-warming:
  - Gently remove wet clothing and replace
  - Insulate with sleeping bag, blankets, or space sheets
  - Insulate from the ground up
  - Encourage drinking of warm, sweet drinks
  - Place in warm environment

Moderate and Severe Hypothermia

- Treatment:
  - Passive rewarming techniques
    - Handle gently; maintain victim in horizontal posi
  - Active core re-warming techniques
    - D5NS heated; avoid Ringer's soln (104-108F)
    - Humidified oxygen (104F)
    - Peritoneal, pleural irrigation
    - Extracorporeal blood rewarming
  - Active external rewarming techniques:
    - Hot water bottles around axilla, groin, neck
    - Forced external warm air
    - Avoid oral liquids if confused stuporous
  - Prepare for transport

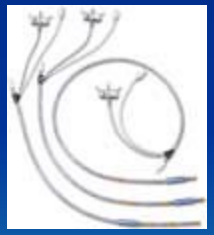
Specific Treatment Algorithm



Danzl DF, Pozos RS: Accidental Hypothermia. NEJM 1994; Vol 331: 1756-17

Current Controversies

- Active Core Re-Warming before Active External Re-Warming
- Re-warming Rates
- Temperature Measurement
- CPR and Life Support



Clinical Scenario II

You are covering the Birkebiener Cross Country Ski Race, when one of the race staff is brought to your tent following the conclusion of the race. He was out all day observing, and now complains of an inability to feel his feet. How would you proceed?

Cold Injury

Reamy BV: Frostbite: Review and Current Concepts. Journal of the American Board of Family Practice. January 1998. Vol. 11, No. 1, 34-40.

Frostbite – Epidemiology

- Most common in adults 30 – 49.
- Most commonly involved extremities:
  - Feet and hands 90% of the time.
  - Ears, nose, cheeks and the penis.
- Risk factors:
  - Alcohol consumption
  - Motor vehicle problems
  - Psychiatric illness

Frostbite – Pathogenesis

Tissue Freezing

↓

Cold-Induced Vasoconstriction

↓

Release of Inflammatory Mediators

Release of Inflammatory Mediators

PGF2, TA2, O2 radicals

Vessel thrombosis

Hypoxia and cell death

Frostbite – Clinical Manifestations

- Initially: numbness that progresses to clumsiness; after rewarming, throbbing that may persist for weeks.
- Favorable initial signs:
  - Sensation to pinprick
  - Skin will indent on palpatio
  - Normal color
  - Blisters with clear fluid

Frostbite – Classification

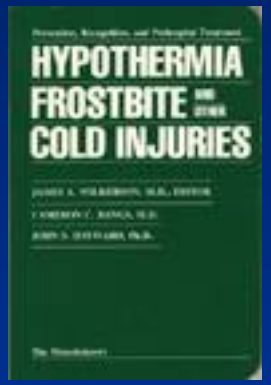
- Classically Four degrees of injury:
  - First – numbness, central white plaque
  - Second – clear or milky blister within the first 24hrs
  - Third – hemorrhagic blisters
  - Fourth – complete necrosis with loss of tissue
- Superficial vs. Deep: treatment is the same as tissue demarcation occurs 22 to 45 days following initial injury.

Frostbite – Diagnosis

- Clinical Diagnosis
- Diagnostic tests may assist in prognosis:
  - From 1 to 3 weeks followir
    injury, Dop
    and a
    can identify
    tissue
  - Bone scan by 2 to 3 weeks

Frostbite – Treatment

- Treatment is directed at reversing:
  - 1. ice crystal formation;
  - 2. vasoconstriction;
  - 3. the release of inflammatory mediators.
- Three Phases: Pre-thaw field care; immediate hospital care; post-thaw care.



Frostbite – Treatment

- Field Care Phase:
  - Warming if transport is anticipated to be less than 2 hrs
  - Protection with splint and bulky dressing
  - Transport to a fixed facility
- Rubbing, alcohol and smoking are contraindicated

Frostbite - Treatment

- Immediate Care Phase
  - Rapid rewarming in water maintained at 104 to 108F for 15 to 30 minutes; red-purple color and pliable texture. Parenteral analgesia.
  - Clear blisters should be debrided and covered in aloe; hemorrhagic blisters should be left intact.
  - Motrin initiated to decrease inflammatory cascade; Tetanus given; Penicillin for 72 hrs.

Frostbite - Treatment

- Post-Thaw Care
  - Admission for all but the most minor cases
  - Daily hydrotherapy aids debridement of devitalized tissue
  - Fasciotomy if compartment syndrome
  - Limited debridement if infection cannot be controlled
  - Amputation delayed until tissue demarcation

Frostbite – Prevention

- Clothing
  - Layering
  - Footwear and gloves
- Acclimatization
- Good physical condition
- Adequate nutritional and hydration status
- Eliminate smoking and alcohol

Clinical Scenario III

You are working in the Marine Corps Marathon Medical Tent when a collapsed athlete is brought in semi-conscious. His rectal temp is 107° F. How do you proceed?

Heat Illness

Bouchama A, Knochel JP: Heat Stroke. The New England Journal of Medicine, Vol 346, No. 25, June 2002.

Definition

- Heat Stroke: a severe illness characterized by a core temp >40C and CNS abnormalities including delirium, convulsions, or coma.
  - Classic: resulting from environmental heat.
  - Exertional: resulting from exertion

"A form of hyperthermia associated with a systemic inflammatory response leading to a syndrome of multiorgan dysfunction in which encephalopathy predominates."

Pathogenesis

- Thermoregulation:
- Acclimatization:
- Acute-Phase Response:
- Heat-Shock Response:

•Coordinated interaction between endothelial cells, leukocytes, and

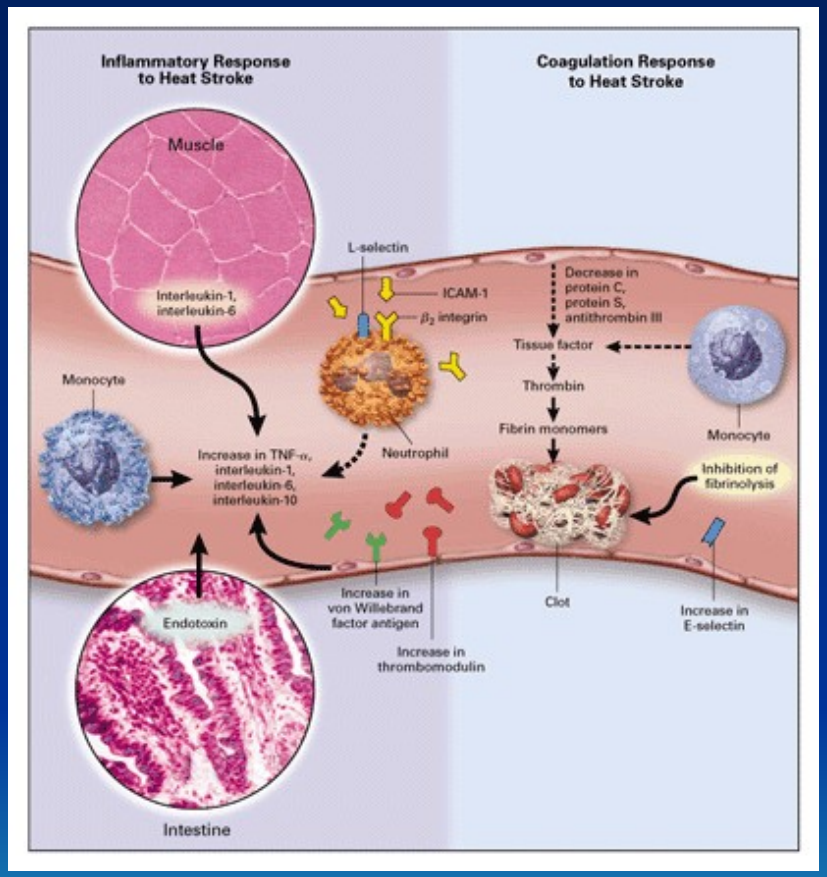
•Heating produces heat shock proteins
•Induce a transient state of heat tolerance
•Help prevent protein denaturation

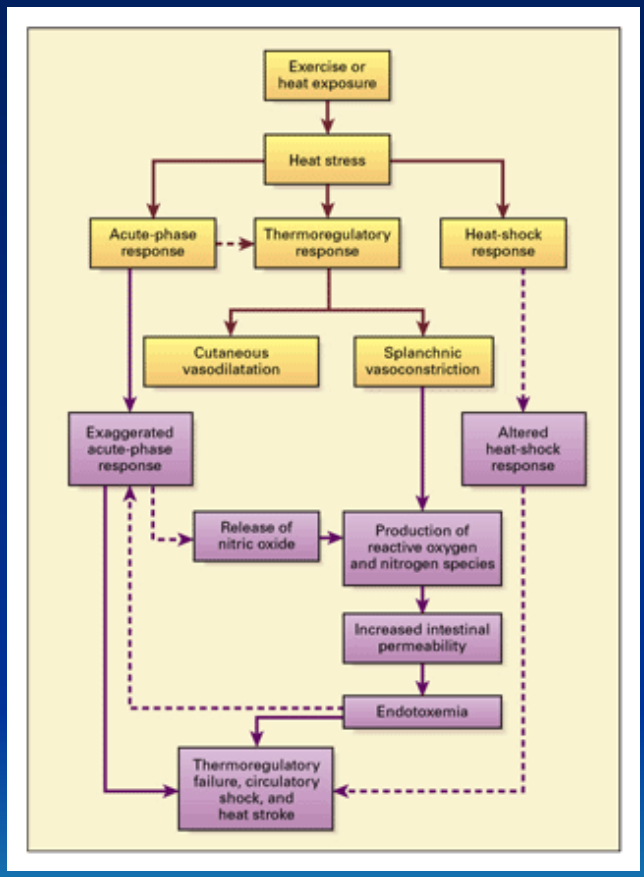
rhabdomyolysis

Pathophysiology of Heat Stroke

- Exaggeration of the Acute-Phase Response
  - Gastrointestinal tract may fuel inflammatory response
  - Ischemia with hyperpermeability
  - Leakage of endotoxins promotes systemic cytokine response
- Alteration of the Heat-Shock Response
  - Aging
  - Lack of acclimitatization
  - Genetic predisposition

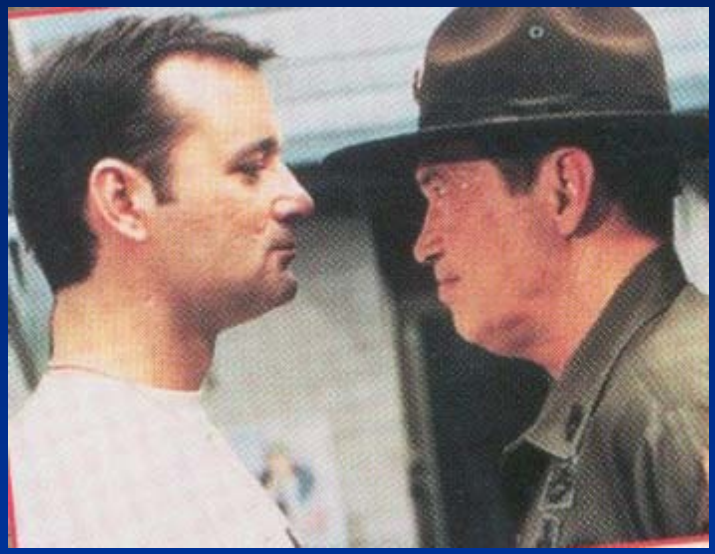
Pathophysiological Mechanisms of Heat Stroke





Risk Factors

- Poor physical fitness
- Lack of acclimitization
- Obesity
- Prolonged exertion
- Lack of sleep
- History of heat injury
- Drug use e.g. ephedra
- Use of heavy equipment or clothing



Clinical Manifestations

- Hyperthermia
  - 40 to 47C
- CNS Dysfunction
  - Inappropriate behavior to coma
  - Seizures may occur especially during cooling

Treatment

- Goals:
  - Transfer heat from the core to the periphery to the external environment.
  - Promote cutaneous vasodilation.
  - Accelerate transfer without compromising the flow of blood to the skin.
    - Lower skin temperature while minimizing cutaneous vasoconstriction and shivering.

Treatment

- ABCs; rescue position; O2 4L NC
- Measure the patient's core temperature with a rectal probe
- Remove clothing and initiate external cooling
  - Cold packs to neck, axilla, groin
  - Continuous fanning
  - Ice water immersion
- IV NS
- Prepare for transfer

Guidelines

- Inter-Association Task Force on Exertional Heat Illnesses Consensus Statement 2003. www.nata.org/industryresources/heatillnessconsensusstatement.pdf
- Suspected Heat Stroke:
  - Immersion in cool tub of water (35 to 59F) with constant core temp monitorin
  - If NA, transport and utilize ice bags, fans, cool water, cold towels.
  - Monitor ABCs
  - IV NS preferable
  - Cease aggressive cooling when core temp reaches 101-102F
  - Transport

Prevention

- Heat stroke is a preventable illness
- Acclimatize
- Proper Scheduling
- Education
- Avoidance of dehydration and salt depletion

Current Controversies

- Cooling Technique
- Benzodiazepines
- Role of Genetics
- Work-up and Return to Play Guidelines for Athletes with Heat Stroke
- Immunomodulation

Clinical Scenario IV

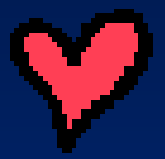
You are working in the Marine Corps Marathon Medical Tent when a collapsed athlete is brought in semi-conscious. His rectal temp is 99° F. How do you proceed?

Exercise-Associated Collapse and Exertional Hyponatremia

Cardiovascular Regulation with Exercise

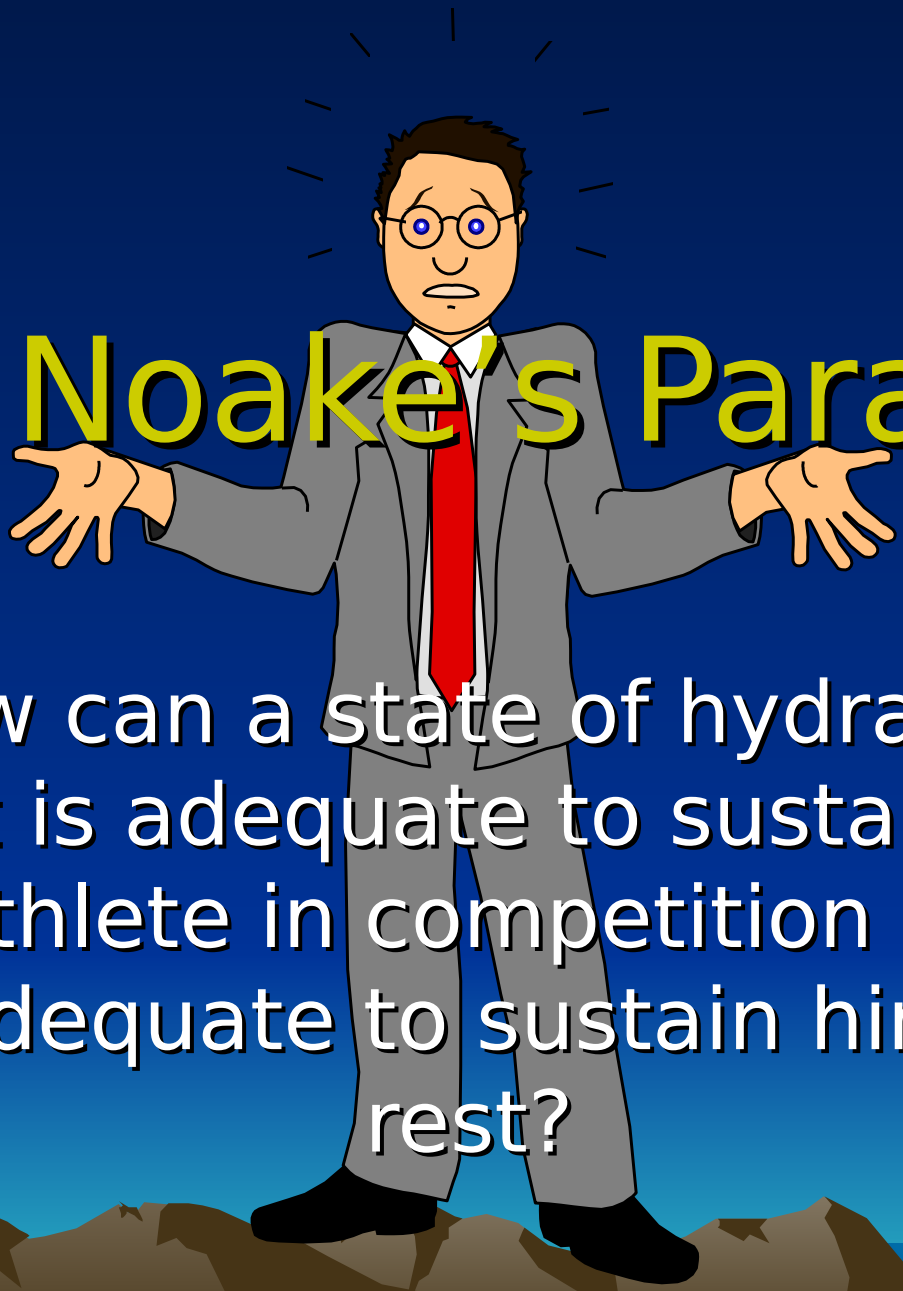
- aerobic exercise results in dramatic shifts in blood distribution.
- cardiac output increases to accommodate an increase in peripheral oxygen demand.
- there is a preferential redistribution of blood flow to the working muscles and away from non-exercising areas.

The “Second Heart”



- During exercise the skeletal muscle functions as a “second heart” as the pumping action of skeletal muscle maintains venous return.
- During muscle contraction, the veins are emptied and the driving pressure back to the heart is substantially increased.
- If the the pumping action of skeletal muscle is lost despite a persistent vasodilation, syncope may ensue.

The Noake's Paradox



How can a state of hydration that is adequate to sustain an athlete in competition be inadequate to sustain him at rest?

The Prevalence and Significance of Post-Exercise Hypotension in Ultramarathon Runners

Holtzhausen LM, Noakes TD, et al: Medicine and Science in Sports and Exercise 1995;27(12):1595-1601.

- Study involving 31/240 runners in an 80k ultramarathon (mean age 38.9 years).
- Pre- and Post-race weights, supine and erect blood pressures, and blood samples:
  - osmolality
  - chemistries
  - glucose

- Average weight loss was 3.5 kg (4.6%).
- Large increase in supine-erect blood pressure differences after the race.
- 81% of runners demonstrated a posture-related difference in systolic blood pressure in excess of 20mmHg.
- No significant correlation was found with weight loss, or plasma volume with systolic blood pressure differences.

Collapsed Ultraendurance Athlete: Proposed Mechanisms and an Approach to Management

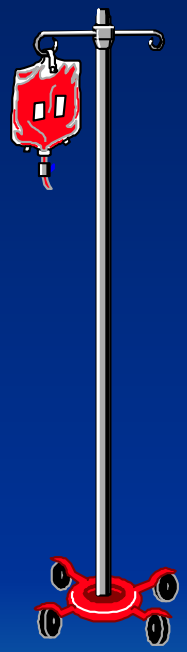
Holtzhausen LM, Noakes TD: Clinical Journal of Sports Medicine 1997;7:292-301.

Management of Collapsed Athletes who are Conscious

- Exercise-Associated Collapse
  - diagnosis of exclusion
  - ingest oral fluids
  - elevate legs and pelvis
  - cool as indicated
  - monitor vital signs
  - most athletes asymptomatic within 30 minutes

Management of Collapsed Athletes who are Conscious

- Who needs an IV?
  - unconscious
  - suspected heat stroke, hyponatremia, hypoglycemia
  - physical exam c/w dehydration
  - persistent emesis
  - persistent tachycardia and hypotension when lying supine with legs and pelvis elevated >10 to 15 minutes



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Exercise-Associated Collapse: An Algorithmic Approach to Race Day Management

Part I of II

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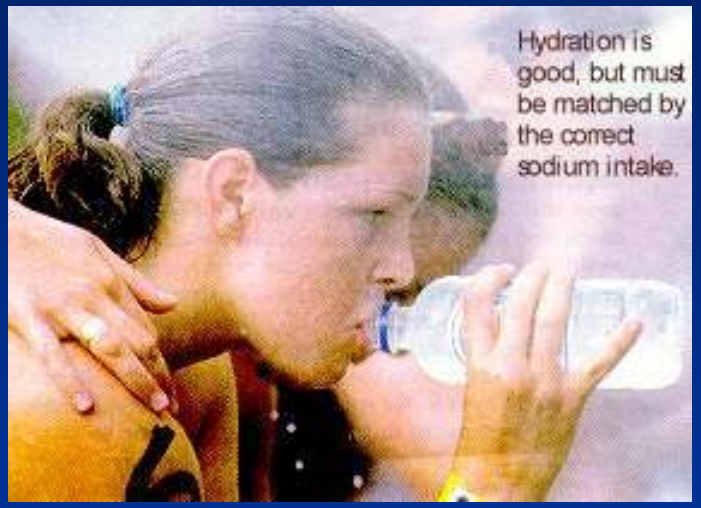
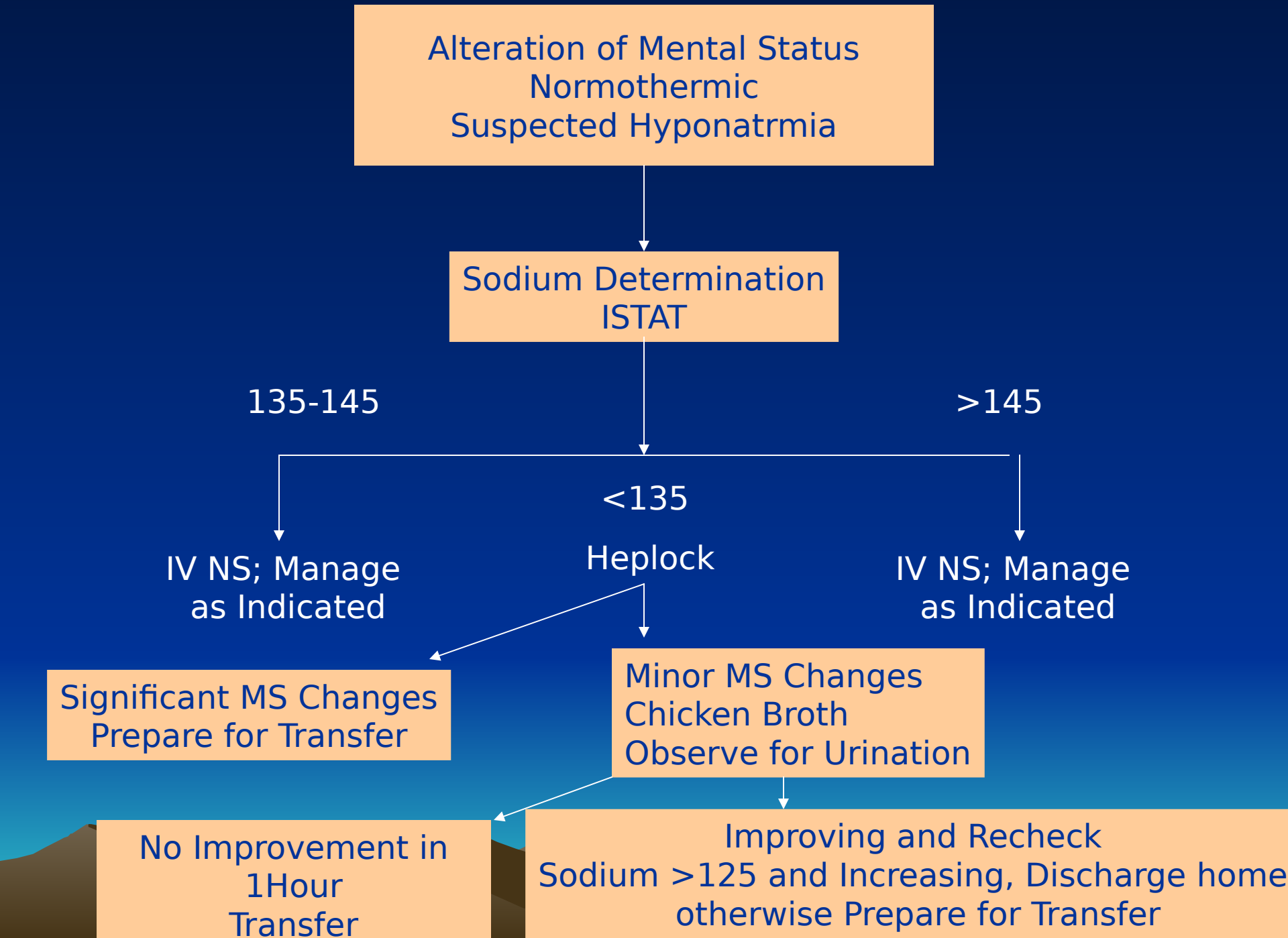
One of the most common diagnoses encountered during a mass participation event is exercise-associated collapse. In the following review, the authors describe the epidemiology, diagnosis, and management of exercise-associated collapse, and introduce an algorithmic approach that they have found useful in managing casualties in mass participation events. Part II will appear in a subsequent issue of AJMS. *(Am J Med Sports. 2003;5:212–217, 229)*

One of the most common diagnoses encountered during a mass participation event is exercise-associated collapse (EAC). EAC is actually a clinical syndrome in which athletes are unable to stand or walk unaided as a result of lightheadedness, faintness, dizziness, or syncope. EAC excludes orthopedic injuries (e.g., sprained ankle, leg cramps) that would preclude completing an event.[1–3] This diagnosis is made after carefully excluding other etiologies that may contribute to an athlete's collapse. In this review, we describe the epidemiology, diagnosis, and management of EAC, and introduce an algorithmic approach that we have found useful in managing casualties in mass participation events.

Exertional Hyponatremia

- Collapse in a runner who is normothermic with mental status changes should be considered to be hyponatremic.
- Personal Communication with Dr. Joseph Verbalis, Georgetown Endocrinology
  - Exertional hyponatremia is a condition of SIADH
    - Inappropriate presence of ADH from an activated cytokine system (intrinsic)
    - Inappropriate hypotonic fluid replacement (extrinsic)




Alteration of Mental Status
Normothermic
Suspected Hyponatrmia
Sodium Determination
ISTAT
135-145
>145
<135
Heplock
IV NS; Manage
as Indicated
IV NS; Manage
as Indicated
Significant MS Changes
Prepare for Transfer
Minor MS Changes
Chicken Broth
Observe for Urination
No Improvement in
1Hour
Transfer
Improving and Recheck
Sodium >125 and Increasing, Discharge home
otherwise Prepare for Transfer

Clinical Scenario V

You have been selected to write the recommendations for water/fluid replacement for a half marathon challenge event for soldiers in Baghdad. What recommendations should you follow?

Exercise and Fluid Replacement

American College of Sports Medicine Position Stand

Medicine and Science in Sports and Exercise. Vol 28(1): January 1996.

Heat and Cold Illnesses During Distance Running

American College of Sports Medicine Position Stand

Medicine and Science in Sports and Exercise. Vol 28(12): December 1996.

ACSM Guidelines

- Pre-hydrate 2 hrs before the race with 500ml.
- Replace during exercise according to sweat loss, which is equivalent to weight loss with 1 pint (500ml) = 1 pound
- Maximum that can be tolerated, or 150 to 300ml every 15 to 20 minutes.
- Cool fluid 59 to 72◦ with flavor enhancer
- Carbohydrate and electrolyte solution for events over one hour.

IMMDA Position Statement

Noakes TD: Fluid replacement during marathon running. Clinical Journal of Sports Medicine Vol. 13, No. 5 September 2003.

Guideline 5

Runners should aim to drink ad libitum 400-800 ml/hr, with the higher rates for the faster, heavier runners competing in warm environmental conditions and the lower rates for the slower walkers/runners completing marathon races in cooler environmental conditions.

[illegible] recommendation for all athletes during exercise.

Clinical Scenario VI

You are fortunate to have been selected to accompany the US Nordic Ski team to the Alps for a training session. While there, a new athlete on the team is under-performing, and complains of persistent headache and insomnia. How would you proceed?

Altitude Illness

Hackett PH et al: High Altitude Illness. New England Journal of Medicine 345: 107-114, 2001.

High Altitude Illness

- Term used to describe cerebral and pulmonary syndromes that can develop in unacclimatized persons shortly after ascent to high altitude.
  - Acute Mountain Sickness
  - High-Altitude Cerebral Edema
  - High-Altitude Pulmonary Edema

Epidemiology

- One study in Summit County, CO: 22% at altitudes of 7000 to 9000 ft; 42% over 10,000 ft.
- Risk Factors:
  - Rate of ascent
  - Altitude reached
  - Sleeping altitude
  - Individual physiology
  - History of altitude illness
  - Residence below 900m

Normal Symptoms at Altitude

- Hyperventilation
- Dyspnea on exertion
- Increased urination
- Awakening at night
- Periodic breathing
  - Periods of hyperpnea followed by apnea of 3 to 10 seconds

Acute Mountain Sickness

- Pathophysiology: hypoxia elicits neurohumoral and hemodynamic (cerebral vasodilation) responses that result in overperfusion of microvascular beds, elevated capillary pressure, capillary leakage, and consequent edema.
- Symptoms: headache with atleast one of the following:
  - Anorexia, nausea, vomiting
  - Fatigue or weakness
  - Dizziness or lightheadedness
  - Difficulty sleeping

Acute Mountain Sickness

- Treatment: (Principles)
  - Further ascent should be avoided
  - Patients with no response to medical therapy should descend
  - At the first sign of HACE immediate descent
- Options:
  - Descend 500m
  - Acclimatize
  - Acetazolamide 250mg BID until symptoms resolve
  - Motrin 400 or 600 mg once

High-Altitude Cerebral Edema

- Symptoms:
  - Defined as the onset of ataxia, altered consciousness, or both in someone with acute mountain sickness or high-altitude pulmonary edema.
- Treatment:
  - Descend
  - If not possible, dexamethasone 8mg, then 4mg q6hrs, O2 2-4 liters, portable hyperbaric chamber

High-Altitude Pulmonary Edema

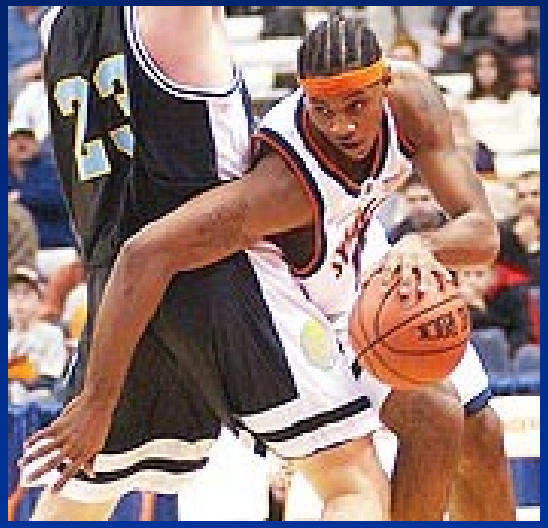
- Accounts for most deaths from high altitude illness
- Symptoms:
  - Decreased performance and dry cough should raise clinical suspicion; pink, bloody sputum is a late finding.
  - Classic: dyspnea at rest; moist cough; severe weakness, drowsiness; cyanosis; tachycardia; rales; tachypnea.

High-Altitude Pulmonary Edema

- Treatment:
  - Descend! Or Portable Hyperbaric Chamber if not possible
  - O2 4-6L/min
  - If descent not possible and oxygen not available, nifedipine 10mg initially, followed by 30mg q12 to 24hrs.

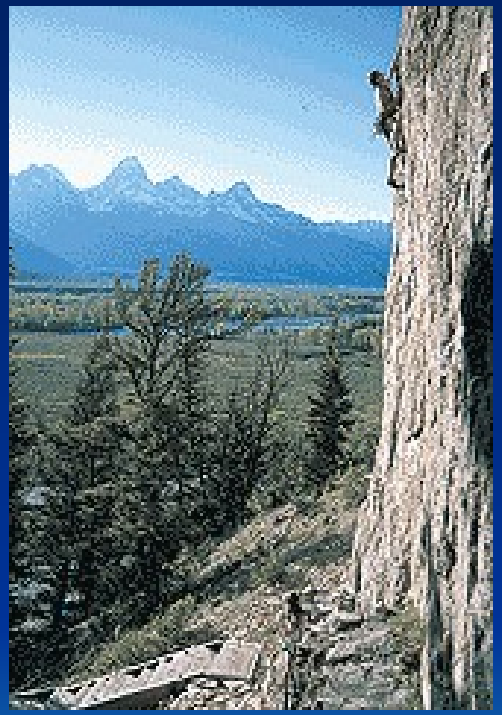
Clinical Scenario VII

You are the team physician for a seacoast college basketball team, selected to play a regional tournament in Denver, CO. The head coach, an avid mountain climber, wants to place the entire team on diamox, what should you advise?



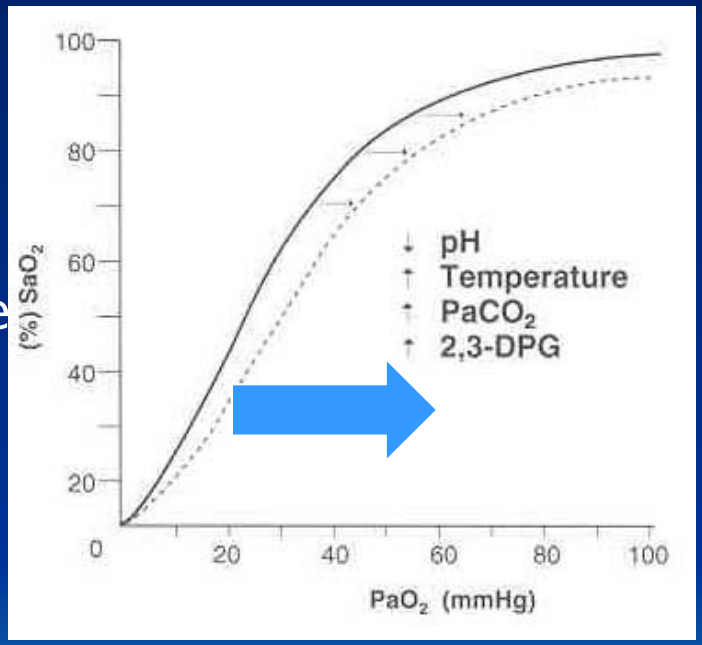
What is Acclimatization?

- A complex process involving multiple physiologic adaptations within the body in response to high altitude, all in an effort to maximize oxygen utilization by the body.



How long does it take to acclimatize?

- The process starts immediately upon arrival at altitude and takes days to weeks, and with chronic exposure, years to mature.
  - ↑Respiratory volume; immediate
  - ↑ Bicarbonate diuresis; immediate/days
  - ↑ Pulmonary artery pressure; immediate
  - ↑ Catecholamine activity; days
  - – Decreased plasma volume; days
  - ↑ Eryrthropoietin; days to years
  - ↑ RBC 2,3-DPG; days
  - ↑ Capillary density; years



Recommendations for Athletes

- Personal Communication with Dr. Ben Levine, University of Texas Southwestern Medical Center
  - For events over 1,500 meters
    - Endurance events: ideal for major competition 2 to 3 weeks at altitude
    - Football/basketball:
      - Ideal: 5 to 6 days for ventilatory acclimatization
      - Practical: skill players 1 to 2 days advance for air resistance compensation
      - Sideline O2 to reduce ventilatory demands; shorter shifts.
      - No medications; may be counterproductive.

Clinical Scenario VIII

While in your sports medicine clinic, a patient requests a prescription for diamox for a planned adventure race in Jackson Hole, WY. Does he need prophylaxis, and if so, what's the right dose and how should he use it?

Altitude Illness Prophylaxis

Prevention of High Altitude Illness

- Acclimatization
- Spend 2 to 3 nights at 8,000 to 10,000 feet before climbing higher
- Avoid sleeping 2,000 ft (600m) higher than the previous night once higher than 8,000 ft (2,440 m)
- Spend an extra night for acclimatization for every 2,000 to 3,000 (600-900m) attained.

Prevention of High Altitude Illness

- High carbohydrate diet appears to lower risk of AMS; adequate hydration status.
- Avoid sleeping pills and alcohol.
- Pharmacologic:
  - Acetazolamide: 5mg/kg/day in 2 to 3 doses for one day prior and first two days at altitude
  - Dexamathasone: 4mg twice a day for one day prior, than continue 3 to 4 days after ascent to avoid rebound
  - Ginkgo Biloba: 80 –120mg BID

Prevention of High Altitude Illness

- More about acetazolamide?
  - Recommended for people going from sea-level to >8,000 feet with not time for acclimatization, or a history of altitude illness
  - Carbonic anhydrase inhibitor: promotes bicarbonate diuresis; decreased CSF production; respiratory stimulant.
  - SE: paresthesias, alters taste of carbonated beverages, polyuria
  - Avoid in breastfeeding mothers, sulfa allergy, pregnancy category C

Summary

- Environmental injuries are challenging for the athlete as well as the primary care sports medicine clinician.
- Sports physicians who manage events where the environment plays an important role need to be aware of:
  - Evolving basic clinical research
  - Consensus clinical treatment guidelines